Project Report
Arizona Iceberg Lettuce Research Council

For period
(July 2004 through June 2005)

Breeding high quality and disease resistant iceberg lettuce cultivars for Arizona

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Growers and shippers throughout the region

SUMMARY

Our objectives are to incorporate disease resistance into crisphead lettuce cultivars and breeding lines adapted to low desert production conditions. Major breeding efforts targeted lettuce big vein, fusarium root rot, lettuce drop (*Sclerotinia sclerotiorum*), tip burn resistance, and powdery mildew. In 2004 we identified new candidate sources of resistance to big vein, powdery mildew, fusarium root rot and tip burn. In replicated tests, we confirmed resistance of previously identified germplasm to big vein, lettuce drop and powdery mildew; we obtained preliminary data on inheritance of resistance to powdery mildew and fusarium root rot. Advanced breeding lines were evaluated and selections were made for resistance to bolting, tip burn, big vein, powdery mildew, and lettuce drop.

INTRODUCTION

Production of iceberg lettuce from December through April is centered in the low desert region of Arizona and California, and is critical to maintaining a year round supply of high quality lettuce. Lettuce production is continually faced with preexisting and new challenges; therefore, development of improved cultivars with superior adaptation and pest resistance is important for sustaining this industry. Our research emphasizes the development of landmark cultivars adapted to early, middle, or late season conditions with resistance to pests, physiological disorders and environmental stresses.

The USDA lettuce breeding project has an ongoing desert program, both in Arizona and in the Imperial Valley. Several landmark cultivars have been released which became the backbone of desert production for many years: Empire, Merit, Climax, and Vanguard. Since the release of those cultivars in the late 1950's additional cultivars were released that have also been useful, including Autumn Gold, Winterset, and Vanguard 75. In recent years, most of the desert production has been in the Yuma area. Therefore nearly all of our on-site work has been done in Yuma and has focused on the production concerns of this region. The objectives have been to develop iceberg lettuce breeding lines possessing 1) bolting resistance for early fall production, 2) big vein, powdery mildew, and downy mildew resistance for mid-winter production, 3) tipburn resistance for late spring production and 4) Lettuce Drop resistance for fall, winter, and spring planting, and 5) Fusarium root rot resistance (Fusarium wilt) for fall, winter, and spring planting.

REPORTS ON SPECIFIC PROJECTS

Big Vein Resistance

Big vein is a serious viral disease in the Yuma Valley, and developments of resistant cultivars are needed to reduce economic damage resulting from big vein. The USDA-ARS in Salinas is currently the only publicly funded big vein resistance breeding program in the US. Partially resistant cultivars adapted for California production have been released which have a reduced frequency of symptomatic plants and/or symptom expression that is delayed until plants reach market maturity. Partially resistant cultivars have not been developed for Yuma production conditions. Furthermore, progress in increasing the level of partial resistance through breeding has been slow. One important reason for this is a lack of genetic variation among resistant cultivars, which are all derived from a few USDA releases. New sources of resistance need to be identified so that higher levels of resistance can be developed.

Big vein is caused by Mirafiori Lettuce Big Vein Virus (MLBVV) which is vectored by the soil fungus *Olpidium brassicae*. Complete resistance or immunity to MLBVV has only been identified in accessions of *Lactuca virosa* L., a distant relative of lettuce. No cultivars possessing immunity from *L. virosa* have been developed. Within the USDA breeding program, *L. virosa – L. sativa* hybrid breeding lines have been identified that have a reduced percentage of symptomatic plants, a type of resistance similar to what is observed in cultivated lettuce. It is likely that the genes responsible for resistance in *L. virosa – L. sativa* hybrids are distinct from those in currently available cultivars. Introgression of this resistance into cultivated lettuce may lead to higher levels of resistance than what is currently available.

The objectives of big vein research are to:

1) Introgress partial resistance from cultivated lettuce into low desert adapted cultivars.
2) Identify new sources of resistance.
3) Introgress resistance from *L. virosa* into cultivated lettuce.

Procedures: A mid-winter field trial was conducted in Yuma, AZ to identify breeding lines and cultivars with big vein resistance under mid-winter production conditions. The experiment was planted on October 15; the incidence of big vein symptomatic plants was recorded on January 7 for 24 F_4 Winterhaven x Pacific, 5 F_5 Pacific x (Pacific x Pavane), and 28 cultivars. Breeding lines with low incidence of big vein symptomatic plants were retained for backcrossing and further selection. The mean disease incidence and 95% confidence interval was calculated for each breeding line or cultivar.

Greenhouse experiments were conducted by inoculating 12 seedlings per line with MLBVV carrying *Olpidium brassiceae* zoospores collected from roots of symptomatic lettuce plants. The inoculated seedlings are transplanted into infested soil, grown in a cool greenhouse, and recorded for disease incidence over the following eight weeks. Three greenhouse experiments were performed during the winter of 2004 – 2005.

1) Three replications of 2 leaf PIs, 289035c (cv. MayKing) and 289042c (cv. Ausztraliai Sarga) were tested with Great Lakes 65 (susceptible control), Pavane (resistant control), and Margarita (resistant control). These leaf PIs had demonstrated a high level of resistance in previous greenhouse evaluations.
2) New sources of resistance are being identified using greenhouse testing. Eighty new PIs were tested in unreplicated trials with Pavane and Great Lakes 65. Ten PIs that were previously selected for resistance were evaluated in a 3 replicate trial with Great Lakes 65, Pavane, and Margarita. These 10 PIs were identified as candidate sources of resistance in a 2003-2004 unreplicated trial.
3) Hybrid materials between *Lactuca virosa* line IVT280 and several European cultivars received from B. Maisonneuve, INRA, Montfavet, France have demonstrated a high level of big vein resistance. We have been working to introgress this resistance into iceberg breeding lines. Two BC_1F_5 lines were selected with resistance greater than the cultivar Pavane. These lines were used as parents to create 7 BC_2 pedigrees. From this, 273 BC_2F_3 *Lactuca virosa – L. sativa* hybrid breeding lines were evaluated for big vein resistance in an unreplicated 2004 – 2005 trial.

Results and Discussion: High incidence of big vein was observed in the Yuma field trial, and good levels of resistance were observed in some breeding lines. Four Winterhaven x Pacific breeding lines had lower percentages of big vein symptomatic plants than Pacific (23% symptomatic), a resistance iceberg control (Table 1). Additionally, all 5 Pacific x (Pacific x Pavane) breeding lines were better than Pacific. All lines performing better than Pacific were retained for further selection and for backcrossing to low desert adapted cultivars. High levels of susceptibility were observed among low desert adapted cultivars, with Winterselect having the least big vein symptomatic plants (41% symptomatic). Further testing of low desert adapted cultivars for big vein resistance will be conducted.

Three years of greenhouse evaluations were completed for 2 leaf lettuce PIs, 289035c (cv. MayKing) and 289042c (cv. Ausztraliai Sarga) (Table 2). When averaged over all three years, both PIs had low percentages of big vein symptomatic plants (289035c = 31% and 289042c = 37%), and were comparable to known sources of resistance Pavane (39%), Margarita (35%), and Pacific (30%). These PIs are currently being evaluated in field trials for their utility in breeding.

Ten PIs that have previously demonstrated resistance were evaluated in a replicated test in 2004 – 2005. Two of these PIs, 342452 (butterhead cv Profos) and 320467 (romaine cv Smaragd), had resistance greater than Pavane (39% big vein) (Figure 1). These PIs will be further trialed in replicated greenhouse and field evaluations. Evaluations of 80 untested PIs identified 34 PIs performing better than Pavane. These lines will be trialed in replicated experiments in 2005 – 2006.

Big vein resistance was observed among BC_2F_3 families that incorporate resistance from *L. virosa*. The mean percent symptomatic plants across pedigrees ranged from 22 – 62% (Table 3). The lowest mean was found in 00-366-3 x Pavane, which was significantly lower than all other pedigrees except 00-366-9 x Clemente. 00-366-3 x Pavane also had the greatest number of transgressive segregants, with 39% of F_3 families performing better than Pavane. This is consistent with *L. virosa* contributing unique genes to result in a higher level of resistance in hybrid progeny. Regardless, sufficient variation was present within all pedigrees to identify BC_2F_3 families that were superior to Pavane. In total, 38 BC_2F_3 families were rated more resistant than Pavane, 21 of which are additionally LMV resistant. Testing of 200 BC_2F_4 families will continue during the winter of 2005 – 2006, and resistant breeding lines will be backcrossed to adapted iceberg cultivars.

Powdery Mildew Resistance

Powdery mildew caused by the fungus *Erysiphe chicoacearum* can damage lettuce production in mid-winter production conditions. Resistance can be an effective control of powdery mildew, although no resistance iceberg lettuce cultivars are known. Resistance is reported in butterhead and romaine cultivars, Imperial 850, and *L. serriola* PIs 234204 and 255665. Of these sources of resistance, the inheritance of resistance is reported only for Imperial 850, which is conferred by a single dominant gene.

Our research objectives are to:

1) Introgress resistance from butterhead cultivars Big Boston, Bremex, Clarion, and Soraya into new iceberg cultivars.
2) Determine the inheritance of resistance in Bremex.
3) Identify new sources of resistance for breeding.

Procedures: A field trial was planted and allowed to become natural infested with *Erysiphe chicoacearum* to evaluate for powdery mildew resistance. Up to 2 replications of 11 F_3 Salinas x Soraya, 14 F_5 Winterhaven x 95-103 (a downy mildew resistant line), 10 F_4 Winterhaven x Big Boston, 7 F_3 Waldmann's Green x Soraya, 5 F_3 Darkland x Clarion, PIs 234204 and 255665 and 56 leaf, romaine and iceberg cultivars were planted on November 9. Plots were evaluated on February 23rd for powdery mildew severity using 1 through 5 scale (1 = no powder mildew – 5 = complete coverage of powdery mildew). Mean severity and 95% confidence intervals were calculated for each line. Powdery mildew free plants from the most resistant families and breeding lines were selected.

Greenhouse testing was used to determine the inheritance of resistance from Bremex. Ninety-six seedlings spread over 8 replications were evaluated from F_2 families of Autumn Gold x Bremex, Clemente x Bremex, and Salinas 88 x Bremex. Seedlings were grown in 3 inch pots and exposed to naturally occurring inoculum. The cotyledons, first 3 true leaves, and adult rosette plants of each seedling was scored as resistant (no sporulation) or susceptible (sporulation). The ratio of susceptible and resistance seedlings was compared to known segregation ratios using chi-square.

Results and Discussion: High levels of powdery mildew infection were observed in the Yuma field trial. Twenty breeding lines had mean powdery mildew severity less than 2, having little to no powdery mildew coverage. From these families, 54 plants were selected from F_4 Winterhaven x Big Boston, F_3 Waldmann's Green x Soraya, F_3 Darkland x Clarion, and F_3 Salinas x Soraya. Several cultivars previously identified as resistant did not perform well in this trial, such as the butterhead cultivar Bremex (mean severity = 3.70) (Table 4). Furthermore, resistance was not observed in PI255665 and in Imperial 850, two genotypes reported in the literature to be resistant. Resistance was observed in PI234204 (mean severity = 2.0), which indicates that this may be a useable sources of resistance. Good resistance was also observed in many modern romaine and leaf cultivars such as Two Star, Shining Star, Red Fox, Red Tide, Waldmann's Green, and Darkland (all mean severity = 2.00). The level of resistance is greater than the currently used resistant sources Clarion and Soraya, and calls into question the value of introgressing resistance from Clarion and Soraya into romaine and leaf cultivars. A second year's data is needed to confirm this result.

F_2 progeny from Autumn Gold x Bremex, Clemente x Bremex, and Salinas 88 x Bremex were evaluated for resistance and susceptibility in a greenhouse test to determine the inheritance of resistance. The Salinas 88 x Bremex progeny fit a 3 resistant : 1 susceptible ratio for cotyledon, first true leaf, and adult plant data. This is consistent with a single dominant gene for resistance. Data from Autumn Gold x Bremex and Clemente x Bremex families did not fit any common segregation ratios. Testing of F_3 families will be used to confirm this result.

Bolting Resistance

High temperatures during fall plantings in the Yuma production region can result in premature bolting. Development of cultivars adapted to high temperature conditions are necessary to expand the production season in Yuma. Our breeding objective is to identify and select iceberg breeding lines with resistance to bolting and appropriate head characteristics for fall planting in Yuma, AZ.

Procedure: A field trial was planted on September 10 at the Yuma Agricultural Center to evaluate 4 F_5 87-714-8 x Autumn Gold and 1 F_4 Autumn Gold x Tiber breeding lines. These lines were evaluated for bolting resistance and head characteristics on November 23 and superior lines were selected.

Results: Nine plants from two F_5 87-714-8 x Autumn Gold families were selected with bolting resistance and head size, shape and cover similar to commercial cultivars. These lines will be evaluated for yield and head characteristics in 2005 – 2006 commercial field plantings.

Tip Burn Resistance

Lettuce planted for harvest in March and April is exposed to high temperatures and increasing day length near market maturity, making the crop vulnerable to tip burn. Tip burn resistance is needed in cultivars adapted to late spring production to insure reliable quality for spring harvested lettuce. Additionally, romaine and leaf cultivars can be extremely susceptible to tip burn, and less breeding has occurred to improve leaf and romaine types for tip burn resistance. No reports exist on the tip burn resistance of leaf and romaine cultivars.

The objectives of this research are to:

1) Develop of iceberg cultivars with a high level of tip burn resistance.
2) Determine the variation for tip burn resistance in romaine and leaf cultivars.
3) Identify romaine and leaf cultivars with tip burn resistance for use as parents in breeding.

Procedure: A late spring tip burn trial was conducted to select iceberg breeding lines with superior tip burn resistance and to identify leaf and romaine cultivars with high tip burn resistance for use as parents in breeding. Three replications of 10 foot plots of 69 leaf, romaine, and crisphead cultivars and 38 Salinas x Vanguard 75 breeding lines were planted at the Yuma Agricultural Center on December 14, 2004. Ten heads per replication were scored for tip burn incidence on April 6th, which was slightly past market maturity. The mean percent tip burn and 95% confidence intervals were calculated for each line using the GLIMMIX macro for SAS.

Late season plantings at the Yuma Agricultural Center work well for tip burn evaluations. However, they are not conducive for selection of head type due to high heat and advanced stages of plant deterioration. Therefore, a second field experiment was planted on December 11 near Wellton, AZ to estimate yield potential. Fifty foot plots were established for six F_5 advanced breeding lines of Salinas x Vanguard 75. Yield was estimated by determining the proportion harvestable heads for each plot after commercial harvest. A 95% confidence interval was calculated for each proportion based on exact binomial distributions. Yield data was calculated as cartons per acre using these statistics.

Results and Discussion: Tip burn incidence was extremely high, ranging from 20 – 100%. Several breeding lines had good resistance relative to known checks. Eleven Salinas x Vanguard 75 breeding lines had better tip burn resistance the Gabilan (47% tip burn), 6 of these were the most resistant in the experiment (Table 5). Thirty plants with good head type were selected from these top 6 lines for further breeding. Yield data from a commercial field demonstrates that 5 of 6 Salinas x Vanguard 75 breeding lines had yields not significantly different than leading commercial cultivars (Table 6). One line, RH04-1711, combined high yield with tip burn resistance greater than Gabilan.

Variation for tip burn incidence was observed among red leaf (ranged 70 – 100%), green leaf (ranged 63 – 100%) and in romaine cultivars (ranged 33 – 100%) (Table 7). However, as is in previous experiments, mean tip burn incidence was higher in green leaf (87%), red leaf (90%), and romaine (79%) types compared to iceberg (70% tip burn). Based on this data, King Henry (romaine 33% tip burn), Xena (green leaf 63 % tip burn), and Red Fox (red leaf 70% tip burn) are the best candidates for use as parents for developing tip burn resistance in romaine and leaf lettuce (Table 5). However, further screening is needed to identify green and red leaf genotypes with improved tip burn resistance.

Lettuce Drop (*Sclerotinia sclerotiorum*) resistance (Collaborative with B. Pryor)

Lettuce drop is a destructive disease of lettuce that occurs worldwide, and is caused by two fungi, *Sclerotinia sclerotiorum* and *Sclerotinia minor*. *S. sclerotiorum* predominates in the Yuma Valley, and can infect lettuce through eruptive germination of sclerotia followed by hyphal invasion of plant crown or roots. *S. sclerotiorum* sclerotia may also produce apothecia, which produce airborne ascospores that can infect lettuce heads. *S. minor* differs from *S. sclerotiorum* in that it infects lettuce only through eruptive germination and predominates in the Salinas Valley. Breeding for *S. minor* resistance in the Salinas Valley has been ongoing, identifying sources of resistance in cultivated lettuce and developing breeding lines. Breeding for resistance to *S. sclerotiorum* in Yuma has not been initiated.

The objectives of this research are to

1) Determine if genotypes resistant to *S. minor* in the Salinas Valley are additionally resistant to *S. sclerotiorum* in Yuma, AZ.
2) Identify sources of resistance to *S. sclerotiorum.*

Procedure: A field trial was conducted at the Yuma Agricultural Center in collaboration with Dr. Barry Pryor (U of AZ). Sclerotia of *S. sclerotiorum* were incorporated into the bed prior to planting. Twenty-two cultivars including the *S. minor* susceptible check Batavia Reine De Glacies and resistant check PI251246 as well as 9 breeding lines were planted with 3 replications into the inoculated beds on November 9. Disease incidence was collected at harvest maturity on January 30.

Results and Discussion: Variation for resistance was observed among the 22 cultivars and 9 breeding lines tested, and genotype rankings largely reflect the results observed with *S. minor* in the Salinas Valley (Figure 2). For example, PI251246, the latin cultivars Little gem, Eruption, and Pavane, and 5 breeding lines derived from Holborn Standard and Great Lakes 54 all had disease incidence below 30%. Additionally, Batavia Reine De Glacies had 60% mortality, making it among the susceptible genotypes tested. This genotype is also highly susceptible to *S. minor*. The cultivars Red Fox, Tehama, Imperial 850, and Two Star were identified as more susceptible than Batavia Reine De Glacies. A second field trial will be conducted in 2005 – 2006 to confirm these results.

Fusarium root rot resistance (a.k.a Fusarium wilt)

Procedure, Results, and Discussion:

1. We will plant race differentials and an inheritance study in a naturally infested commercial field. A single planting in a Fusarium-infested field in the Yuma area did not have sufficient disease incidence to permit evaluation of F_2 families from crosses of a susceptible cultivar with three resistance sources (see below).

2. Determine inheritance of resistance in greenhouse tests. Previous results from limited numbers of F_1 and a small sample one F_2 family indicated the resistant in lettuce is recessive. This past year, data from greenhouse tests of 267 plants in three F_2 families from crosses of susceptible 'Vanguard' by 'Salinas', 'Salinas 88', and 'Costa Rica No. 4' confirmed recessive inheritance of resistance to Fusarium wilt.

3. Identify new sources of resistance in greenhouse tests. Six romaine cultivars previously found resistant in field tests at Yuma were highly resistant in greenhouse tests: Appollo, BOS 9021, Conquistador, Fresheart, Slugger, and King Louie. These lines may be useful for as sources of resistance for iceberg cultivars.

Table 1. Big vein resistance in F_4 Winterhaven x Pacific, F_5 Pacific x (Pacific x Pavane), and adapted cultivars conducted in a winter Yuma field trial.

Breeding Line	Pedigree	Generation	Type	Percent Big Vein	95% Confidence Interval	
					lower	upper
RH04-1142	Winterhaven x Pacific	$F_{3:4}$	Head	0	0	56
RH04-1135	Cultivar - Res Check		Latin	6	3	12
RH04-1165	Pacific x (Pacific x Pavane)	$F_{3:5}$	Head	10	6	18
RH04-1163	Pacific x (Pacific x Pavane)	$F_{3:5}$	Head	10	6	17
RH04-1174	Winterhaven x Pacific	$F_{3:4}$	Head	12	7	22
RH04-1140	Winterhaven x Pacific	$F_{3:4}$	Head	14	4	40
RH04-1154	Winterhaven x Pacific	$F_{3:4}$	Head	15	7	28
RH04-1164	Pacific x (Pacific x Pavane)	$F_{3:5}$	Head	17	11	25
RH04-1166	Pacific x (Pacific x Pavane)	$F_{3:5}$	Head	23	16	31
RH04-1167	Pacific x (Pacific x Pavane)	$F_{3:5}$	Head	23	16	32
Pacific	Cultivar - Res Check		Head	23	16	32
RH04-1161	Winterhaven x Pacific	$F_{3:4}$	Head	26	16	40
RH04-1147	Winterhaven x Pacific	$F_{3:4}$	Head	27	16	40
RH04-1173	Winterhaven x Pacific	$F_{3:4}$	Head	29	20	40
RH04-1137	Winterhaven x Pacific	$F_{3:4}$	Head	35	18	57
RH04-1151	Winterhaven x Pacific	$F_{3:4}$	Head	37	26	50
Winterselect	iceberg		Head	41	36	46
RH04-1141	Winterhaven x Pacific	$F_{3:4}$	Head	42	32	52
RH04-1149	Winterhaven x Pacific	$F_{3:4}$	Head	47	34	60
RH04-1146	Winterhaven x Pacific	$F_{3:4}$	Head	47	34	60
RH04-1148	Winterhaven x Pacific		Head	48	38	58
RH04-1171	Winterhaven x Pacific		Head	49	38	60
RH04-1152	Winterhaven x Pacific		Head	49	38	61
RH04-1139	Winterhaven x Pacific		Head	50	22	78
RH04-1138	Winterhaven x Pacific		Head	50	25	75
Salinas	iceberg		Head	52	41	63

Table 1 Continued

Breeding Line	Pedigree	Generation	Type	Percent Big Vein	95% Confidence Interval	
					lower	upper
Honcho II	iceberg		Head	54	44	63
RH04-1158	Winterhaven x Pacific		Head	55	45	64
RH04-1170	Winterhaven x Pacific		Head	56	45	66
RH04-1153	Winterhaven x Pacific		Head	58	48	68
Del Oro	iceberg		Head	60	50	69
Supercoach	iceberg		Head	60	48	71
RH04-1155	Winterhaven x Pacific		Head	61	51	71
Coyote	iceberg		Head	62	52	70
RH04-1160	Winterhaven x Pacific		Head	63	51	73
RH04-1162	Winterhaven x Pacific		Head	64	39	84
Bubba	iceberg		Head	65	55	73
RH04-1159	Winterhaven x Pacific		Head	66	56	74
Del Rio	iceberg		Head	68	57	78
RH04-1143	Winterhaven x Pacific		Head	68	57	78
RH04-1136	Winterhaven x Pacific		Head	69	55	80
Grizzly	iceberg		Head	72	62	80
Winterhaven	iceberg		Head	75	64	84
Great Lakes 65	iceberg		Head	80	71	86
Syn 352	iceberg		Head	82	73	88
Vanguard 75	iceberg		Head	82	71	89
RH04-1150	Winterhaven x Pacific		Head	83	64	93
RH04-1172	Winterhaven x Pacific		Head	84	74	90
Wolverine	iceberg		Head	86	77	91
Great Lakes 65	iceberg		Head	90	81	95
Sunbelt	iceberg		Head	91	83	96

Table 2. Percent big vein symtpomatic plants over 3 years of greenhouse testing of PI289035c, PI289042c, Great Lakes 65, Margarita, Pavane, and Pacific.

	Percent Big Vein					
				3 year total		
	Year 1	Year 2	Year 3	Mean	Upper	Lower
289035c	27	38	26	31	19	48
289042c	8	29	53	37	23	53
GreatLakes 65	100	59	81	74	59	85
Margarita		41	28	35	21	53
Pacific	50		25	30	15	51
Pavane	58	32	39	39	25	56

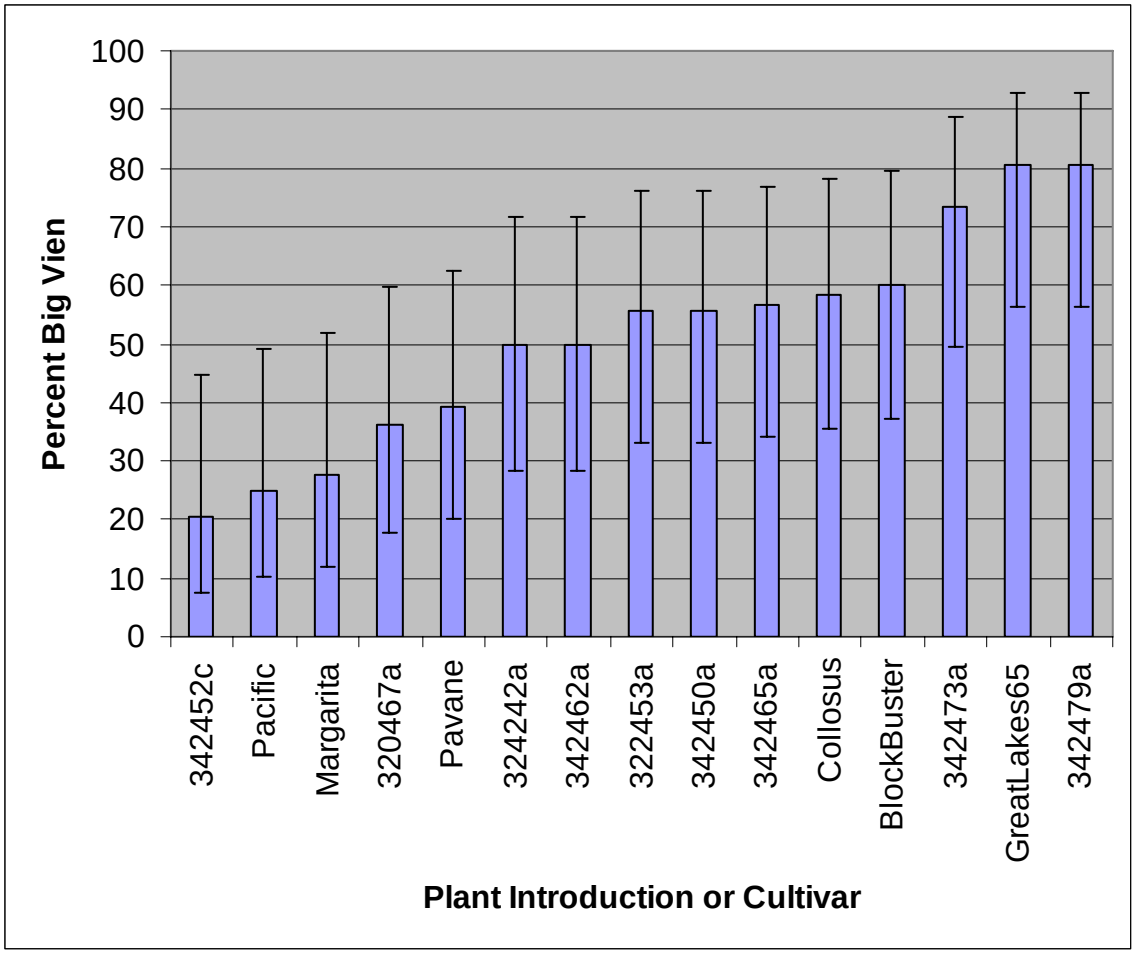

Figure 1. Percent big vein symptomatic plants in 10 Plant Introductions and 7 cultivars tested in a replicated greenhouse trial.

Table 3. Percent big vein symptomatic plants in $F_{2:3}$ (*L. virosa-L. sativa) x L. sativa* hybrids, Pavane, Pacific, Clemente, Salinas 88, Great Lakes 65, and *L. virosa* accessions IVT280.

Line	No. plants tested	No. families tested	Percent symptomatic plants			Range of Family Means	Percent families better than Pavane
				95% C.I.			
			Mean	Lower	Upper		
03-366-3 x Salinas 88	145	21	51	39	62	0 – 86	14
03-366-9 x Salinas 88	271	38	62	53	70	13 - 100	3
03-366-9 x Clemente	262	38	42	33	50	0 - 100	21
03-366-3 x Pavane	155	23	22	14	33	0 – 50	39
03-366-3 x Salinas	361	55	58	51	65	0 - 100	9
03-366-3 x Pacific	385	63	58	51	64	0 - 100	10
03-366-9 x Salinas	233	35	56	46	64	0 - 100	14
Salinas 88	23		78	44	94		
00-366-3	20		18	4	52		
00-366-9	21		65	34	88		
Clemente	20		60	30	84		
Great Lakes 65	21		100	0	100		
IVT280	22		0	0	100		
Pacific	20		50	22	78		
Pavane	21		14	3	50		

Table 4. Powdery mildew severity of 55 cultivars and 2 Plant Introductions (PI) in a 2005 Yuma, AZ field trial.

Powdery Mildew Severity Class[a]	Genotypes[b]
1.1 - 2.0	Two Star[1], Shining Star[1], Red Fox[2], Red Tide[2],PI 234204, Waldmann's Green[1], Darkland[3]
2.1 - 3.0	Calicel[4], Tehema[1], Fila[5], Valmaine[3], Green Towers[3], Parris Island Cos[3], Artic King[5], Clarion[5], Corelli[5], Hilde[5], Soraya[5], Big Boston[5], Cindy[5], Clemete[3]
3.1 - 4.0	Vanguard 75[4], Anthem[5], PI 255665, Allegiance[5], Fresh Heart[3], Margarita[5], King Henry[3], Dark Green Boston[5], Green Forest[3], Bremex[5]
4.1 - 5.0	Syn 352[4], Cibola[4], Diamond[4], Supercoach[4], Winterhaven[4], Desert Spring[4], PIC714[3], Del Oro[4], Del Rio[4], Salinas[4], Autumn Gold[4], Bubba[4], Tiber[4], Wolverine[4], Kofa[4], Coyote[4], Head Master[4], Icon[4], Jackal[4], Big Sur[4], Red Coach[4], Silverado[4], Pacific[4], Grizzly[4], Imperial 850[4], Yuma[4]

[a]Rating Scale: 1=no powdery mildew, 2=powdery mildew on lower leaves, 3=powdery mildew on middle leaves, 4=powdery mildew upper leaves, 5=powdery mildew on entire plant

[b]Cultivar type indicated with superscript number. 1=green leaf, 2=red leaf, 3=romaine 4=iceberg, 5=butterhead, PI = Plant Introduction

Table 5. Percent tip burn in 69 green leaf, red leaf, romaine, and iceberg lettuce cultivars in a December planted Yuma field trial.

Percent Tip Burn	Genotypes[a]
20 - 40%	King Henry[3], Vanguard 75[4]
41 - 60%	Gabilan[4], Pacific[4], PIC714[3], Medallion[3], Clemente[3]
61 - 80%	Xena[1], Siskyou[3], Silverado[4], Parris Island Cos[3], Sundance[4], Tiber[4], Red Fox[2], Navajo[4], Caesar[3], Northstar[1], Head Master[4], Salinas[4], Sniper[4], Brave Heart[3], Fresh Heart[3], Triton[3], Envy[1], Cochise 47[4], Green Forest[3], Vanmax[4], Rubicon[3]
81 - 100%	New Red[2], Ocean Green[1], Beretta[3], Valmaine[3], Big Star[1], Conquistador[3], Iceberg[4], Diamond[4], Shining Star[1], Darkland[3], Gorilla[3], PIC454[3], Green Vision[1], Calmar[4], Green Towers[3], Desert Spring[4], Red Line[2], Heart's Delight[3], Coastal Star[1], Genecorps Green[1], Red Tide[2], Lobjoits[3], Sureshot[4], LaBrillante[4], Grand Rapids[1], Grand Rapids TBR[1], Two Star[1], Block Buster[4], Sunbelt[4], Avalanche[3], Dark Green Boston[5], Tehema[1], Calicel[4], Great Lakes Mesa 659[4], Aragon Red[2], Deep Red[2], Red River[2], Rueben's Red[3], Citori[3], Gladiator[3]

[a]Cultivar type indicated with superscript number. 1=green leaf, 2=red leaf, 3=romaine 4=crisphead, 5=butterhead

Table 6. Percent packout, cartons per acre, and percent tip burn of 6 F_4 Salinas x Vanguard 75 breeding lines and 6 commercial cultivars.

			Percent Packout			Cartons per acre[1]			
				95% confidence Interval			95% confidence Interval		Percent
Line	Total Plants	Plants remaining	Estimate	Lower	upper	Estimate	lower	upper	Tip Burn[2]
RH04-1711	89	12	87	78	92	937	845	997	40
RH04-1703	92	5	95	88	98	1024	953	1062	85
RH04-1719	85	11	87	78	93	943	845	1008	83
RH04-1693	92	14	85	76	91	918	823	986	86
RH04-1718	93	28	70	60	78	757	650	845	43
RH04-1731	70	6	91	82	96	990	888	1040	53
Gabilan	84	34	60	30	51	645	325	553	47
Cochise47	90	7	92	85	96	999	921	1040	79
Diamond	88	9	90	82	95	973	888	1029	86
Navajo	100	3	97	92	99	1051	997	1073	73
Silverado	120	8	93	87	97	1011	943	1051	66
Sureshot	107	10	91	84	95	982	910	1029	93

[1]/ based on 26000 heads per acre

[2]/ Data from a Yuma Ag Center Trial

Table 7. Mean percent tip burn and range in 89 green leaf, red leaf, romaine, and iceberg type genotypes.

		Tip Burn			
			95% confidence interval		
Lettuce type	No. Genotypes	Percent	Lower	Upper	Range of genotype means
red leaf	7	90	79	95	70 – 100
green leaf	13	87	79	92	63 – 100
Romaine	28	79	73	84	33 – 100
Iceberg	41	70	64	75	20 – 100

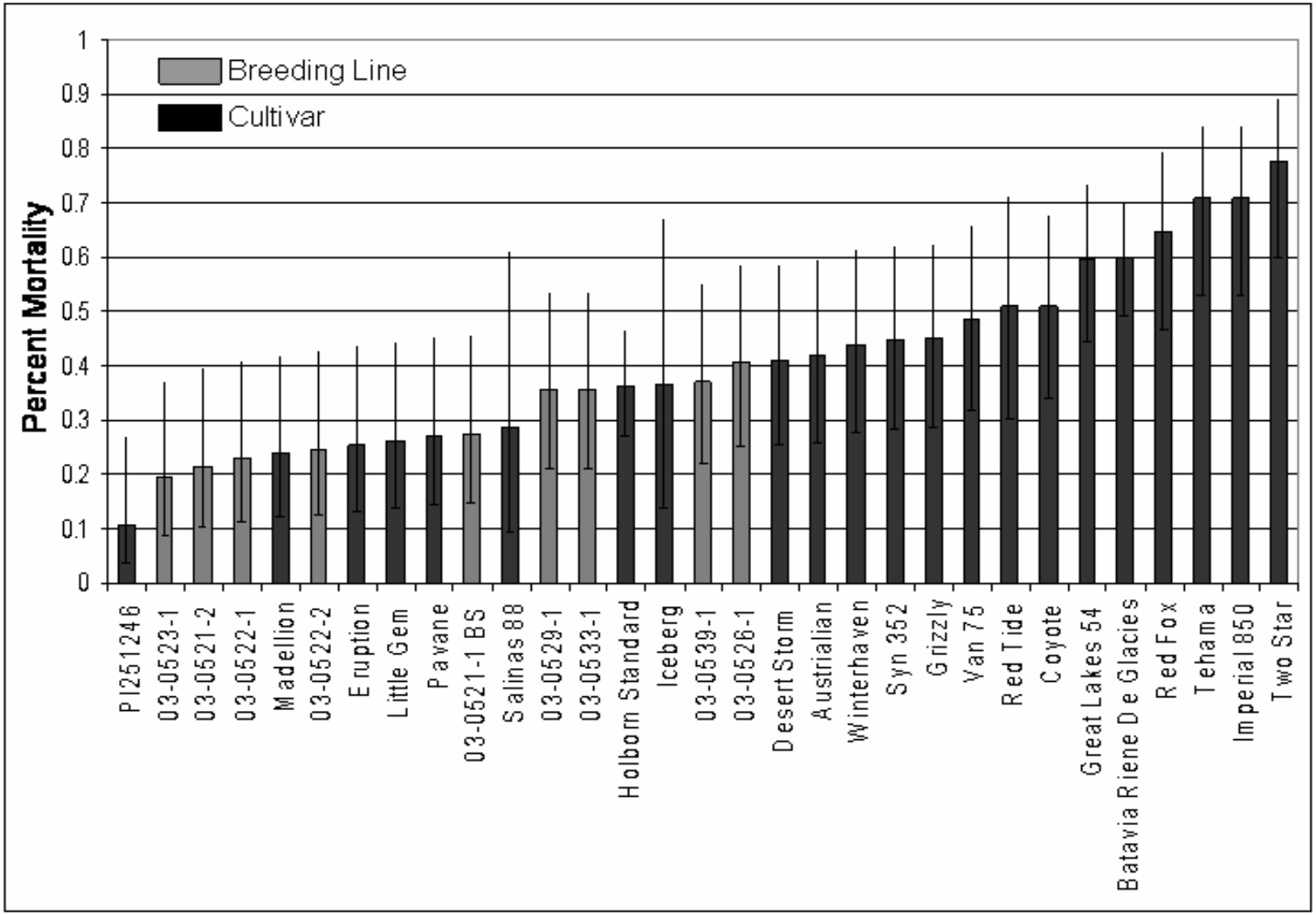

Figure 2. Lettuce drop (Sclerotinia sclerotiorum) percent mortality of 22 cultivars and 9 breeding lines in an inoculated 2004 – 2005 Yuma, AZ field trial.

Breeding high quality and disease resistant iceberg lettuce cultivars for Arizona (July 2004 through June 2005)

Powdery mildew resistance trial nearing market maturity at the Yuma Agricultural Center.

High mortality in an inoculated Lettuce drop trial at the Yuma Agricultural Center.